

Appl. S.N. 10/642,371
Amdt. dated November 14, 2006
Reply to Office Action of August 15, 2006
Docket No. 100110197-1

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In the specification:

Please revise paragraph number [0003] as follows:

One embodiment of the present invention provides a mold for the nanoimprinting process. The mold contains one or more protruding features having nanoscale dimensions, i.e., a lateral dimension of about ~~one~~ 1 nm to 100 μ m. In a preferred version, a plurality of protruding features form a regular pattern. In another version, the protruding feature has the shape of a pillar. In yet another version, the mold is comprised of a substrate and a molding layer, for example, a silicon substrate and a silicon dioxide molding layer.

Please revise paragraph number [0004] as follows:

Another embodiment of the present invention provides a method for preparing such a mold for use in nanoimprinting. This method includes the steps of overlaying one or more nanoscale masking elements on top of the mold, etching portions of the mold not covered by the masking elements to form protruding features in the mold; and removing the masking elements on top of the protruding features. In a preferred version, the nanoscale masking elements are ~~self-assembled~~ self-assembled dots, islands or nanoparticles having a diameter of about ~~one~~ 1 nm to 1 μ m, although other geometric shapes, such as a porous membrane, are possible. In ~~the~~ a preferred version, nanoparticles are formed by evaporation of metal on the surface of the mold. Alternatively, a film comprising a self-assembled particle array is prepared at the surface of a Langmuir-Blodgett trough and transferred to the molding layer. The protruding features formed by the method will typically have a lateral dimension of about ~~one~~ 1 nm to 100 μ m. When nanoparticles are used as a masking element, the protruding features will have the shape of a pillar.

Please revise paragraph number [0006] as follows:

A preferred embodiment is a membrane electrode assembly, which includes an ion conductive membrane having a top surface and one or more nanoscale recesses.

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Each recess will have a bottom, and side walls between the top surface of the membrane and the bottom of the recess. The membrane electrode assembly also includes a catalytic electrode layer coating the top surface of the membrane and the bottom of the recess(es). The ion conductive membrane can be a cation- or proton-transporting polymeric electrolyte material, but preferably includes salts of polymers containing anionic groups. A preferred shape for the recess is that of a nanohole. More preferably, a plurality of recesses form a regular pattern, wherein the recesses are separated by spaces of about ≈ 1 nm to 100 μ m. In another preferred version, the bottom of the recess is parallel to the top surface of the membrane and the side walls are perpendicular to the top surface of the membrane and the bottom of the recess.

Please revise paragraph number [0014] as follows:

Fig. ~~5A~~ 5 shows another embodiment where nanoscale catalyst dots are deposited on the surface of a substrate.

Please revise paragraph number [0017] as follows:

The mold is patterned with protruding and/or recessed features, such as pillars, holes, dams, and trenches, with a minimum lateral feature size of about ≈ 1 nm. The typical depth (or height) of a feature is from ≈ 1 nm to 100 μ m, depending on the desired lateral dimension. In certain embodiments, the desired lateral dimension of the protruding and/or recessed feature may be less than or equal to about 10 μ m, about 1000 nanometers, about 500 nanometers, about 100 nanometers, about 90 nanometers, about 80 nanometers, about 70 nanometers, about 60 nanometers, about 50 nanometers, about 40 nanometers, about 30 nanometers, about 25 nanometers, about 20 nanometers, about 15 nanometers, about 10 nanometers, about 5 nanometers, about 3 nanometers, about 2 nanometers, about ≈ 1 nanometer and any range derivable therein. Similarly, the spacings between features are generally about ≈ 1 nm to 100 μ m.

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Please revise paragraph number [0020] as follows:

The nanoparticles have sizes ranging from about ~~one~~ 1 nm to 1 μ m. In certain embodiments, the diameter of the nanoparticles may be less than or equal to about 1000 nanometers, about 500 nanometers, about 100 nanometers, about 90 nanometers, about 80 nanometers, about 70 nanometers, about 60 nanometers, about 50 nanometers, about 40 nanometers, about 30 nanometers, about 25 nanometers, about 20 nanometers, about 15 nanometers, about 10 nanometers, about 5 nanometers, about 3 nanometers, about 2 nanometers, about ~~one~~ 1 nanometer and any range derivable therein. ~~They~~ The nanoparticles can be made of metals, dielectrics, semiconductors, ceramics, polymers or combinations thereof. ~~The nano-particles~~ nanoparticles can be prepared by direct evaporation of thin metals, such as Pt or Cr, on the surface to form self-assembled nanoparticles. The size and spacing of the particles can be controlled by the selected metals and deposition conditions in direct metal deposition. Alternatively, deposition of self-assembled nanoparticles, made of metals, dielectrics, semiconductors, ceramics, polymers or combinations thereof, from, e.g., a Langmuir trough, or other physical or chemical methods may be utilized to prepared the nanoparticles used in certain embodiments of the present invention. In one embodiment, the spacing can be controlled more accurately by attaching molecules to the particles and preparing a regular particle array by a Langmuir trough.

Please revise paragraph number [0021] as follows:

~~Nano-particles~~ Nanoparticles that are homogeneous in size can be made, with controllable sizes ranging from about ~~one~~ 1 nm to 1 μ m. Accordingly, nanoscale features at resolution levels much less than that of ~~the state-of-the-art~~ the state-of-the-art e-beam lithography can be attained using preferred versions of the present method. Compared with e-beam lithography, this method is also cheap and quick. Moreover, by making ~~one mold~~ one mold, one can use it to generate many copies.

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Please revise paragraph number [0026] as follows:

Figs. 3A-3C show steps for the imprinting process in accordance with one embodiment. As shown in Fig. 3A, the protruding features 16 of the mold can be pressed directly into a membrane 24 and then separated from the membrane (for details of the imprinting process, see also U.S. Patent Document 5,772,905, incorporated herein by reference).

Please revise paragraph number [0031] as follows:

Generation of patterns of protruding or recessed shapes in the membrane, such as holes, pores, bumps, pillars, walls or trenches, that have a lateral dimension of diameter of about ≈ 1 nm to 100 μ m and side walls having a depth (or height) of about ≈ 1 nm to 100 μ m, are also contemplated as alternative versions of the present invention.

Please revise paragraph number [0034] as follows:

The catalytic material may be deposited by chemical means including vacuum deposition methods, such as vacuum sublimation, sputtering, vapor transport, and chemical vapor deposition. The thickness of the catalytic layer is preferably in the range from about ≈ 1 nm to 1 μ m. The thickness of the catalytic layer may be such that the coating of the recessed features and the surface of the membrane remain substantially disconnected. Certain embodiments of the present invention can include an appropriate chemical bonding process as an additional step after deposition to ensure that there is a chemical bond between the catalytic material deposited and the membrane surface. Examples of an appropriate chemical bonding process includes laser heat application, oxidation, reduction as well as other thermal means and other chemical applications that promote reactions.

Please revise paragraph number [0035] as follows:

In a preferred embodiment, shown in Fig. 4A, a layer of metal (e.g., platinum) is deposited vertically by e-beam evaporation on the polymer surface. As shown in the

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cross-section of Fig. 4B, the metal will be in fact deposited on the bottom of the ~~nanoholes~~ nanoholes and top surface of the polymer, leaving the vertical ~~side-walls~~ side walls at least partially uncoated. The metal layer deposited on the top surface (beyond the hole areas) is continuous and can be in contact with a porous current collector that allows efficient electron conduction and fuel delivery.

Please revise paragraph number [0038] as follows:

For example, in a hydrogen/oxygen fuel cell, hydrogen ions are formed at the anode, travel across the solid electrolyte, and combine with oxygen at the cathode to form water. Since the solid electrolyte is generally a proton conducting polymeric material that ~~doesn't~~ does not conduct electrons, electrical current flows through an external circuit, generating electricity. This structure is sandwiched between two porous, electrically conducting current-collectors which allow efficient electron transfer as well as delivery of fuel to the catalyst and electrolyte.

Please revise paragraph number [0041] as follows:

Figure Fig. 5 illustrates another embodiment, where the same mold and imprinting process can be used to form nanoscale catalyst dots 30 on an arbitrary substrate 32, such as SiO_2 and Al_2O_3 , using a lift-off process to remove a molded layer on top of a substrate 32. The sizes and spacings of the catalyst dots 30 are the same as the ~~nanoparticles~~ nanoparticles 14 deposited on the surface in Fig. 1A. By using the methods described above to control the sizes and spacings, one can design special catalyst arrays to improve catalysis efficiency for special processes. For example, an array of Pt nanoscale dots may be employed when compounds containing Si-H are used to synthesize polymeric materials. Similarly, catalyst dots could be made on a solid electrolyte material rather than deposited over holes as described above.